Residual Heat Removal System

- Low Pressure Coolant Injection (LPCI)
- Containment Spray
  - DW spray
  - SP Spray
- Suppression Pool Cooling.
- Shutdown Cooling
- Fuel Pool Cooling
- Standby Coolant Supply

Chapter 10.4

Objectives

1. Identify the purposes of the residual heat removal (RHR) system.
2. Summarize the purpose, function and operation of the following major system components:
   a. Suppression pool and shutdown cooling suction valves
   b. RHR pumps
   c. Minimum flow valve
   d. RHR heat exchanger
   e. Containment spray spargers
   f. Line fill
3. Explain the purpose, operation and flow path for each of the following RHR system modes of operation:
   a. Low pressure coolant injection (LPCI)
   b. Containment spray
   c. Suppression pool cooling
   d. Shutdown cooling (SDC) and head spray
   e. Standby coolant supply mode
   f. Fuel pool cooling assist
   g. Testing

Objectives

4. List the automatic and manual initiation signals for the LPCI mode of operation

5. Describe the system response to an automatic LPCI initiation signal from the standby alignment or while operating in any mode in objective 3

6. Describe how the residual heat removal (RHR) system interrelates with:
   a. Reactor Recirculation system
   b. Primary containment
   c. Nuclear Steam Supply Shutoff system
   d. Emergency AC power system
   e. Automatic Depressurization system
   f. Core Spray system
   g. Reactor Building Closed Cooling Water system
   h. Reactor Building Service Water System
   i. Fuel pool Cooling and Clean up system

Residual Heat Removal System

PURPOSES:

Low Pressure Coolant Injection Mode:
auto initiates to restore and maintain desired water level in the reactor vessel following a Loss Of Coolant Accident (LOCA).

Containment Spray Mode:
condenses steam and reduces airborne activity in the primary containment following a LOCA. (SP and DW spray)

Suppression Pool Cooling Mode:
removes heat from the suppression pool.

Residual Heat Removal System

- **Shutdown Cooling and Head Spray Mode:**

  removes decay heat from the reactor core following a reactor shutdown and removes residual heat from upper reactor vessel internals during a cooldown.

- **Standby Coolant Supply Mode:**

  To provide a means of flooding the primary containment with service water.

- **Fuel Pool Cooling Mode:**

  To provide fuel pool cooling when the capacity of the Fuel Pool Cooling and Cleanup system is not adequate.

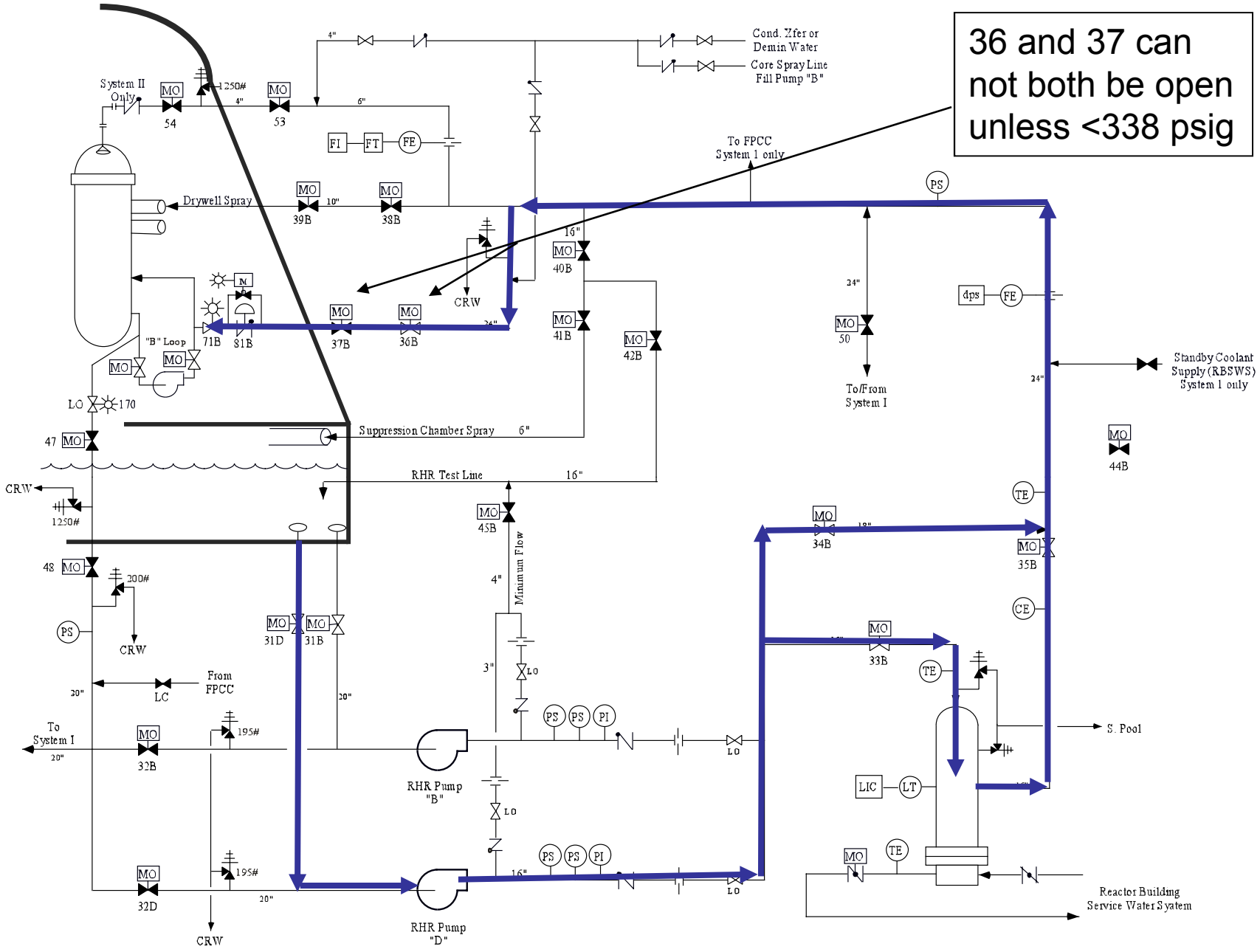
Normal Line-up

- RHR is in the standby lineup for LPCI during normal operation.
- LPCI is the only mode that auto initiates to flood the vessel in an accident condition

Level 1 (-132.5 inches)

OR

High DW pressure (1.69 psig)


36 and 37 can not both be open unless <338 psig
Cond. Xfer or Demin Water
Core Spray Line Fill Pump "B"
System II Only
MO 54
1250#
MO 53
FI FT FE
To FPCC System 1 only
Drywell Spray
MO 39B
MO 38B
MO 40B
MO 41B
MO 42B
CRW
MO 37B
MO 36B
"B" Loop
71B
81B
MO 50
To/From System I
dps FE
Standby Coolant Supply (RBSWS) System 1 only
MO 44B
LO 170
47 MO
Suppression Chamber Spray 6"
RHR Test Line 16"
CRW 1250#
MO 45B
Minimum Flow
MO 34B
MO 35B
48 MO
200#
PS
CRW
MO 31D
MO 31B
From FPCC
LC
MO 33B
TE
CE
To System I
MO 32B
195#
RHR Pump "B"
PS PS PI
LO
S. Pool
LIC LT
MO 32D
195#
CRW
RHR Pump "D"
Reactor Building Service Water System

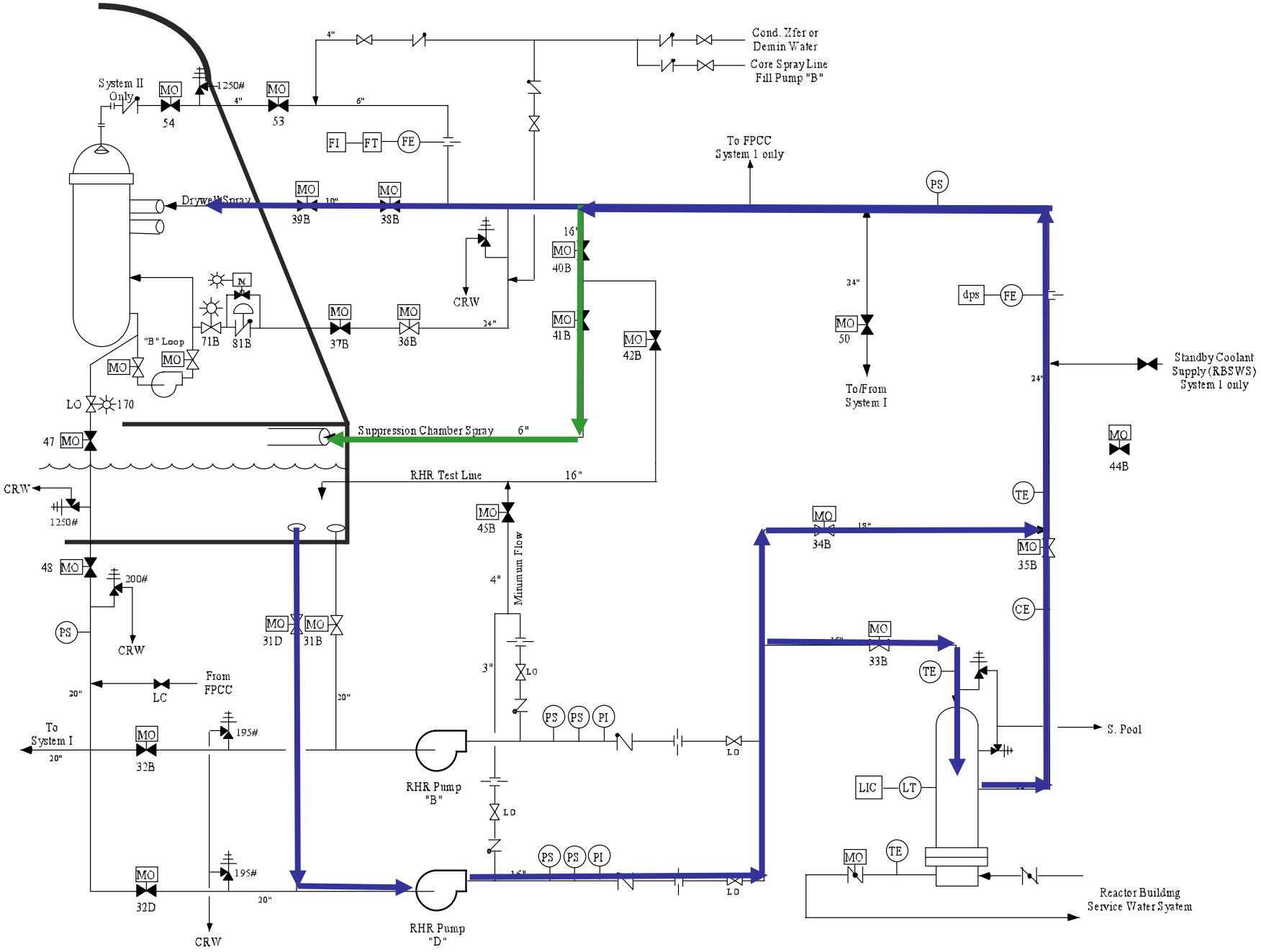
Containment Modes

- Containment Spray and Suppression Pool Cooling modes assist in maintaining containment integrity.
  - Containment Spray is an emergency function.
  - Suppression Pool cooling may be either emergency or off-normal.

Containment Spray

- Drywell Spargers – 2 rings at top of drywell
- Suppression Chamber Spargers – 2 rings at top of suppression pool chambers
  - Division I supplies one sparger each in the Drywell and Suppression Pool
  - Division II supplies the 2nd DW and SP spargers.

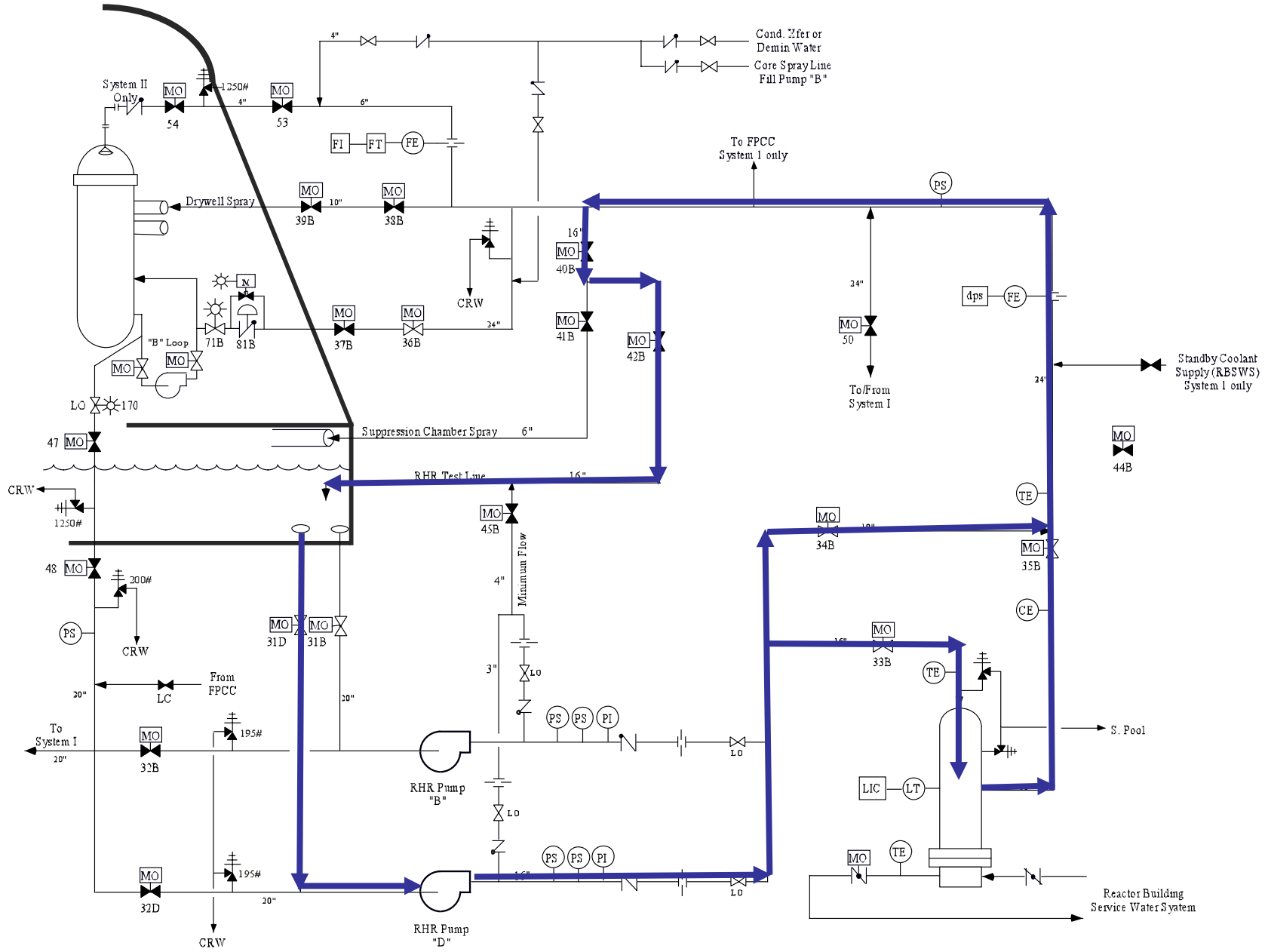
Spray Lineups



Suppression Pool Cooling

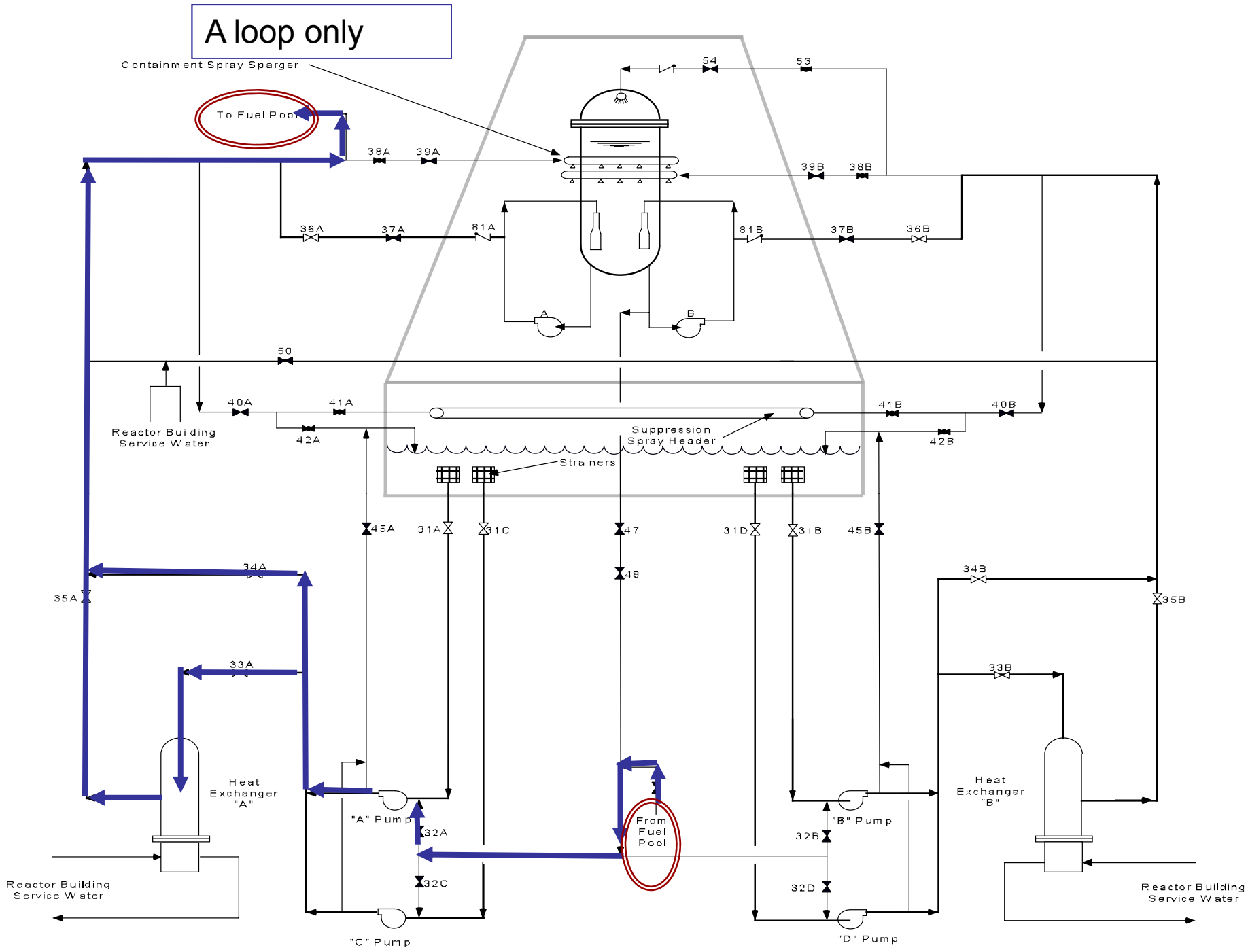
Water from suppression pool is cooled in the RHR heat exchangers.

- Heat comes from various sources
  - –HPCI
  - –RCIC
  - –SRV’s
  - –LOCA
- Test Line up uses the same flow path


Cond. Xfer or Demin Water
Core Spray Line Fill Pump "B"
System II Only
1250#
54
53
FI
FT
FE
To FPCC System 1 only
Drywell Spray
39B
33B
CRW
40B
41B
42B
50
To/From System I
dps
Standby Coolant Supply (RBSWS) System 1 only
71B
81B
37B
36B
"B" Loop
LO
170
47
Suppression Chamber Spray
6"
RHR Test Line
16"
44B
CRW
1250#
45B
Minimum Flow
34B
35B
TE
48
200#
31D
31B
4"
3"
CE
PS
PI
CRW
From FPCC
LC
20"
33B
To System I
32B
195#
RHR Pump "B"
S. Pool
LIC
LT
32D
RHR Pump "D"
Reactor Building Service Water Syatem

Fuel Pool Cooling

- FPCC Augmentation
- Early in refueling outages when off-load decay heat generation is highest

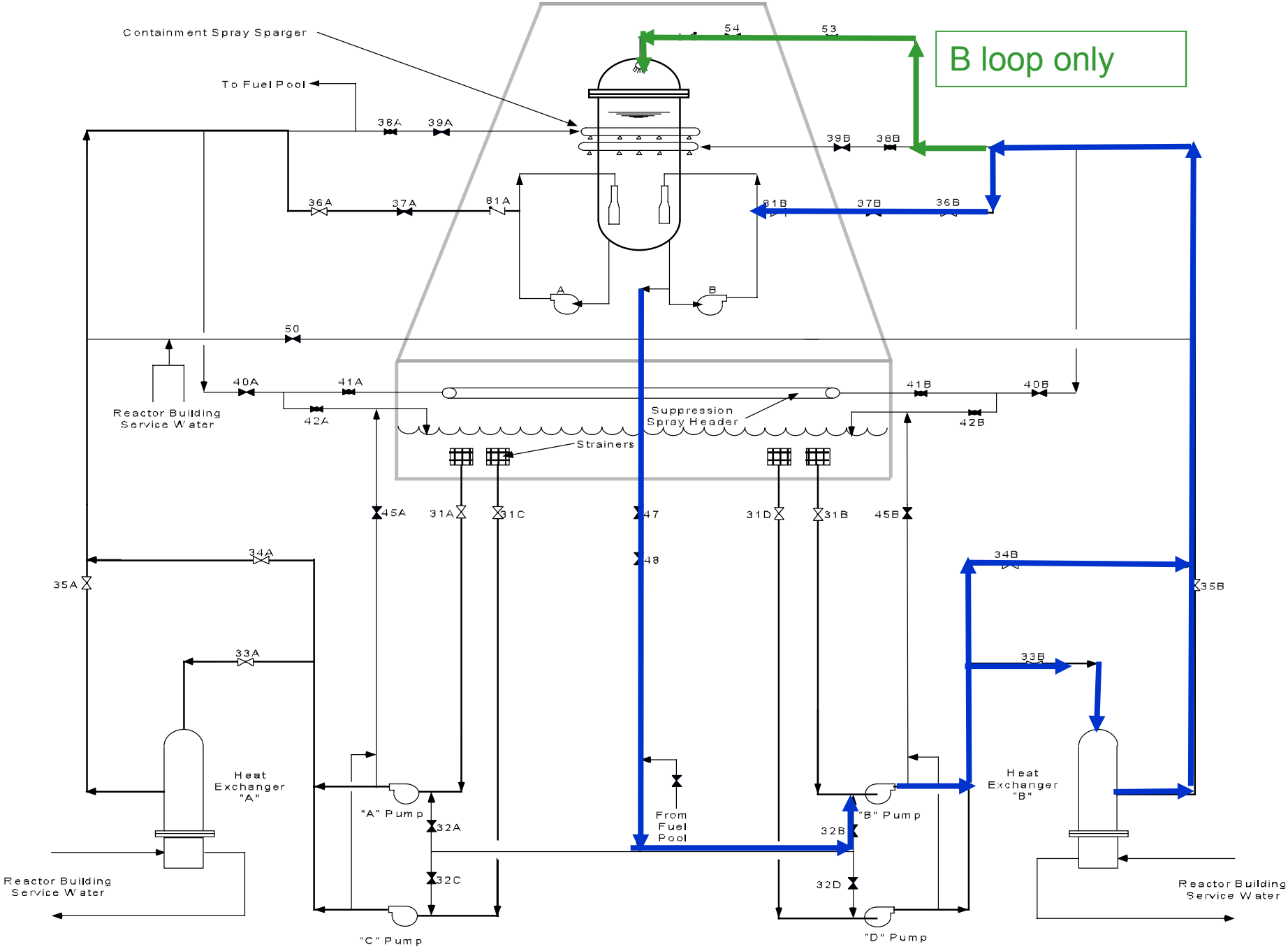

A loop only
Containment Spray Sparger
To Fuel Pool
54
53
38A
39A
39B
38B
36A
37A
81A
81B
37B
36B
A
B
50
40A
41A
41B
40B
Reactor Building
Service Water
42A
42B
Suppression
Spray Header
Strainers
45A
31A
31C
47
31D
31B
45B
34A
35A
48
34B
35B
33A
33B
Heat
Exchanger
"A"
"A" Pump
32A
From
Fuel
Pool
"B" Pump
32B
Heat
Exchanger
"B"
Reactor Building
Service Water
32C
32D
Reactor Building
Service Water
"C" Pump
"D" Pump

Shutdown Cooling Mode

- Removes decay heat when shutdown.
- Head Spray is used to remove heat from the thick upper head region

Conditions

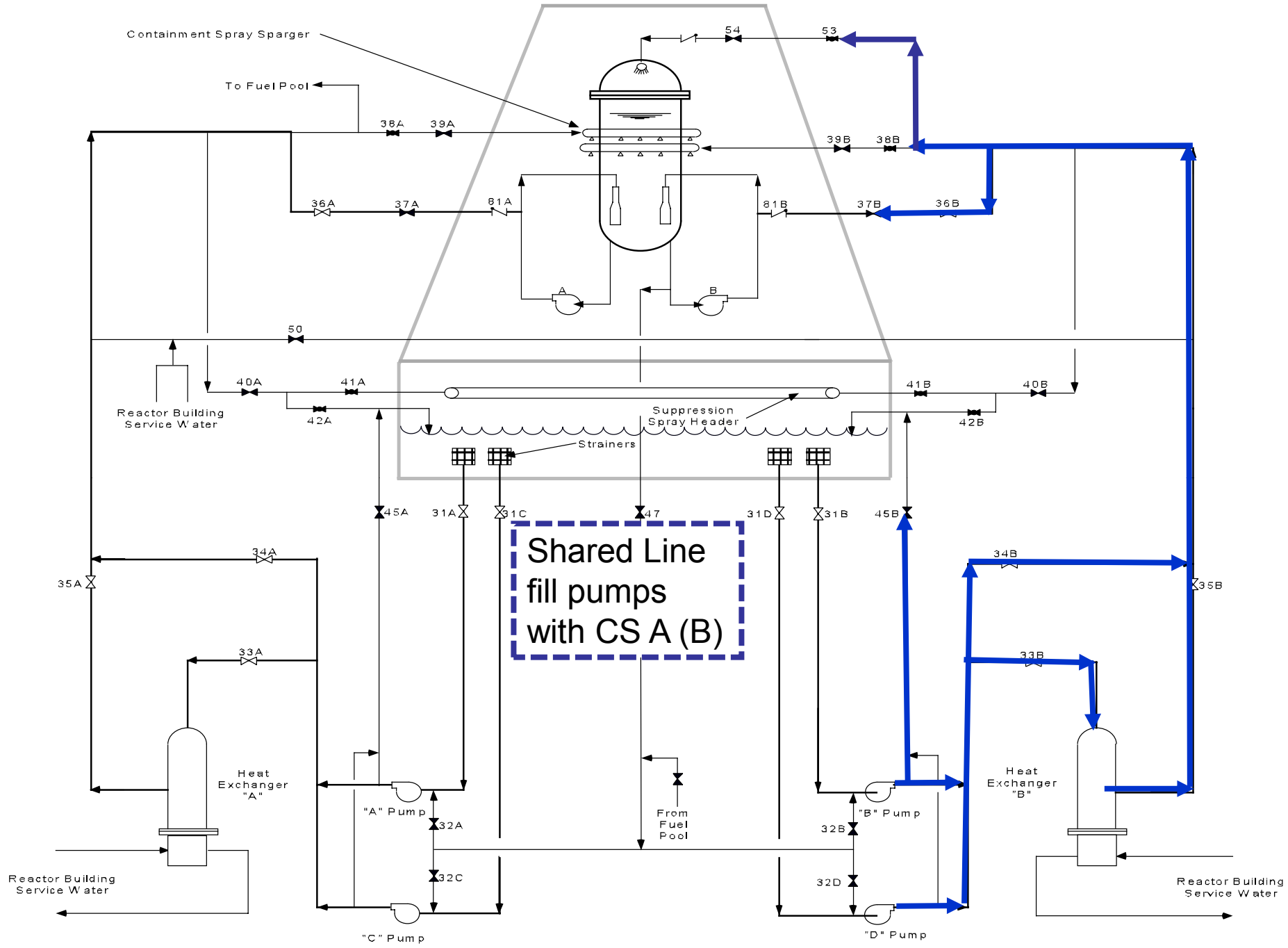
- Reactor at low pressure
- Suction from A recirculation loop suction side
- Return to either recirculation loop discharge side
- Recirculation pump discharge valve shut to ensure flow to the vessel.


B loop only
Containment Spray Sparger
To Fuel Pool
54
53
38A
39A
39B
38B
36A
37A
81A
31B
37B
36B
A
B
50
40A
41A
41B
40B
Reactor Building
Service Water
42A
42B
Suppression
Spray Header
Strainers
45A
31A
31C
47
31D
31B
45B
34A
35A
48
34B
35B
33A
33B
Heat
Exchanger
"A"
"A" Pump
32A
From
Fuel
Pool
"B" Pump
32B
Heat
Exchanger
"B"
Reactor Building
Service Water
32C
32D
Reactor Building
Service Water
"C" Pump
"D" Pump

Line Fill

- Keeps discharge line full with water to minimize injection times
- Helps prevent water hammer.

Uses the same pump as the Core Spray Line Fill


Containment Spray Sparger
To Fuel Pool
54
53
38A
39A
39B
38B
36A
37A
51A
51B
37B
36B
A
B
50
40A
41A
41B
40B
Reactor Building
Service Water
42A
42B
Suppression
Spray Header
Strainers
45A
31A
31C
47
31D
31B
45B
Shared Line
fill pumps
with CS A (B)
34A
35A
34B
35B
33A
33B
Heat
Exchanger
"A"
"A" Pump
From
Fuel
Pool
"B" Pump
Heat
Exchanger
"B"
32A
32B
32C
32D
Reactor Building
Service Water
Reactor Building
Service Water
"C" Pump
"D" Pump

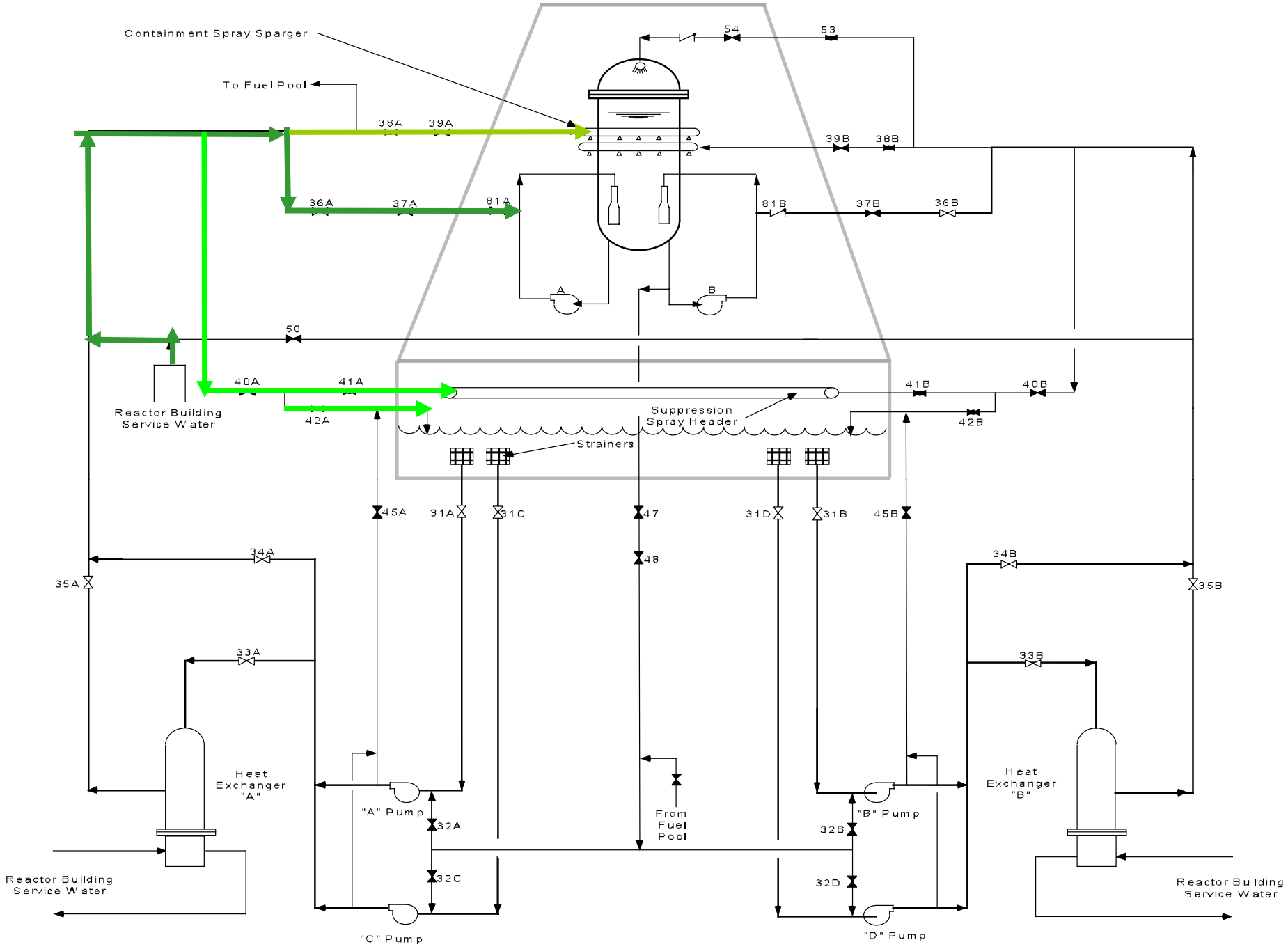
Standby Coolant Injection (SBCI)

- LPCI and CS don't work &
- Level continues to decrease!

- SBCI adds sea/lake/river water to the vessel

If that doesn't work!

Fill the DW with SBCI


Containment Spray Sparger
To Fuel Pool
54
53
38A
39A
39B
38B
36A
37A
81A
81B
37B
36B
A
B
50
40A
41A
42A
41B
40B
42B
Reactor Building
Service Water
Suppression
Spray Header
Strainers
45A
31A
31C
47
31D
31B
45B
34A
48
34B
35A
35B
33A
33B
Heat
Exchanger
"A"
"A" Pump
From
Fuel
Pool
"B" Pump
Heat
Exchanger
"B"
32A
32B
32C
32D
Reactor Building
Service Water
Reactor Building
Service Water
"C" Pump
"D" Pump

LPCI Initiation Signals align RHR from standby, SPC, test, SPS, and DWS to the LPCI mode

RPV level 1

OR

High Drywell Pressure

OR

Manual Arm and Depress Pushbuttons

Start Sequence

- Pumps start immediately and run on min flow to the SP.
- RPV < 310 psig, the Recirculation Pump Discharge valves close (shut in 33 seconds)
- Pump shutoff head is 238 psig.
- When system flow rises above 2350 gpm, into the vessel, minimum flow valve closes

LPCI / SDC Interlock

Prevents inadvertent draining of the reactor vessel.

- **Shutdown cooling suction valves are interlocked with the suppression pool suction valves.**
- **If the pumps SP suction valve is not fully closed, the SDC suction valve cannot be opened.**

System Interrelations

Recirculation system

- The SDC and HS mode suction is taken on the suction of the "B" loop. LPCI and SDC injection is into the discharge of both recirculation loops.
- A LPCI initiation signal shuts recirculation pump discharge valves at <310 psig.

Primary Containment system (Section 4.1)

- The RHR System's standby lineup suction path is from the suppression pool.
- RHR flow can be returned to the suppression pool from:
  - pump minimum flow
  - suppression chamber spray
  - test return
- Redundant drywell spray spargers are supplied from the RHR system.
- The standby coolant supply mode allows flooding the containment.

System Interrelations

Nuclear Steam Supply Shutoff system (Section 4.4)

- NSSSS sends isolation signals to various RHR valves.

Emergency AC Power system (Section 9.2)

- Emergency AC power system provides a reliable power source for RHR System.

Core Spray system (Section 10.2)

- Core Spray (CS) system shares line fill pumps with the RHR system. CS loop A (RHR A (system I). CS loop B (RHR B system II)

Automatic Depressurization System (Section 10.2)

- ADS receives an open permissive signal when RHR pump discharge pressure is >125 psig.

System Interrelations

Reactor Building Closed Loop Cooling Water System

- RBCLCW system provides cooling water to the RHR pump seals.

Reactor Building Service Water System

- Supplies cooling water for the RHR heat exchanger
- Can be used to flood containment via RHR lines in the RHR standby coolant supply mode.

Fuel Pool Cooling and Cleanup System

- System I (RHR A) of the RHR system may be used to assist in fuel pool cooling.